Hypothesis Test: Single- and Double-Rimmed Basketball Hoops

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Executive Summary

The problem I am solving is whether single- or double-rimmed basketball hoops provide the best shooting accuracy.

To investigate this problem, I will use the single and double rimmed hoops at the park, which are comparable in all of their other features. I will take many shots on the court for both hoops and record how many baskets I make. This will be done for layups and mid-range shots using different techniques. Using this data, I can compare the shooting rates at the same location for both baskets to determine which basket is better. The hypothesis being tested is that the type of hoop has no effect on the success rate.

In addition, to take advantage of the data that was collected, other hypotheses will also be tested:

- The side that a shot is taken on (to the left or right of the basket) has no effect on performance.
- The shot technique for distance shots (shooting from the chest or the standard way) has no effect on performance.

The test shows that the hypotheses cannot be rejected when using small alpha values, (alpha=5%). Usually, only one or two test cases will indicate that the hypothesis can be rejected, while the rest are in support of the hypotheses. More rigorous testing (higher alpha values) may be needed for a definitive answer. The decision of what alpha values are appropriate for these tests is unclear.

Introduction

Problem Statement

The purpose of this report is to explore the difference in shooting performance with single and double rimmed basketball hoops. There is currently no quantitative data on the internet that investigates this topic, and many casual basketball players do have a strong preference for one kind of hoop over the other.

Background Info

The writer of hoopsjunction.com says that shooting on the double rim is objectively harder, so it is good to use this rim when practicing since it will improve your performance on the (easier) single rim hoop. The writer says that the double rim is less forgiving for shots that hit the inside of the rim, since they may bounce out after ricocheting off the inside of the rim. For a single rim, this does not happen as often, since there is a smaller surface to rebound off of.

My personal experience is that the ball can bounce out as the writer describes, but this happens on a very small percentage of shots. Many shots go cleanly through the hoops (swishes) or they are misses. Out of the shots that hit the inside of the rim, I do not think that a very large percentage of them (<5%) will ricochet out. Physically, it seems unlikely for the ball to reverse direction back out of the hoop by hitting the uneven interior surface of the double-rim hoop.

Double rim

Single rim

Hypothesis

Considering the fact that the hoops art made of the same material and the inner and outer diameters of the hoops are the same, I predict that there will be no difference in performance between the two hoops. For the other two topics being investigated (shooting side and technique), the default hypothesis will be that they have no effect on performance.

Procedures

To test these hypotheses, I took 20 shots at 3 different parts of the court for each basketball hoop. One of these was the free throw. This is a standard shot that will serve as a good basis of comparison between the two hoops. This shot is not too far from the hoop that fatigue will become a significant factor. It is also not too close that the test becomes trivial. Due to these advantages, the other two locations being tested are the same distance from the hoop as the free throw. Thus, the only difference is the angle of the shot. Both of these shooting points are at a 45 degree angle from the centerline of the court (one on the left side, one on the right side). This way, any changes in performance can be attributed to the angle change, and the left or right side performance can be compared directly. Two shooting techniques are used for this experiment. One is the standard shot using the flick of the wrist, and the other is the shot from the chest. For the former shot, I consulted two sources [2] and [3] in the references, to ensure that it was done with consistency. Tests were also conducted for layups, for which I followed the techniques and guidelines of [4].

Below are the results of the data collection. The bottom row shows the total number of shots made successfully for each of the tests. These tests include shooting from the left and right side and at the free throw for the two shooting techniques mentioned above. Layups were conducted on the left and right side. This was all done for both the single and double-rimmed hoops.

	single rim							
	standard technique			chest technique			layups	
	free throw	45 deg left	45 deg right	free throw	45 deg left	45 deg right	left side	right side
1		1		1	1		1	
2	1	1			1			1
3		1	1		1	1		1
4	1			1	1			1
5	1		1		1		1	
6		1	1		1	1	1	
7	1						1	1
8					1			1
9	1		1	1				1
10						1		1
11			1		1	1		1
12			1					1
13	1				1			
14		1				1		1
15			1		1	1		1
16		1	1	1	1			
17	1		1		1			1
18	1				1	1	1	
19	1					1		1
20					1			1
totals	9	6	9	4	14	8	5	14

	double rim							
	standard technique			chest technique			layups	
	free throw	45 deg left	45 deg rig	free throw	45 deg left	45 deg rig	left side	right side
1					1			
2	1	1				1	1	
3			1			1	1	
4		1	1	1		1		1
5	1		1		1			
6		1			1	1		1
7	1	1						1
8						1	1	
9	1			1				
10	1	1	1			1		1
11				1		1		
12	1	1					1	1
13	1					1		1
14	1				1		1	
15			1					1
16	1	1		1				1
17	1							
18			1	1	1			1
19	1					1		1
20	1			1		1		1
totals	12	7	6	6	5	10	5	11

The data did not need preprocessing because there were no clear trends that affected the data. That is, tiredness at the end or better focus at the beginning were not significant factors.

Statistical Methods

The goal of this experiment is to test whether the expectation is the same for each of the two shots being compared. Since this is a bernoulli variable, the expectation is the same as the percent chance of success, P, which the experiment wants to compare. I used the f-test first to compare the sample variance of the two kinds of shots that I was comparing. Then, I used the appropriate t-test to determine if the expectations are (most likely) equal or not. This involved constructing a confidence interval for each of the trials. If 0 is in the confidence interval, the hypothesis cannot be rejected.

Results

Below are the expectations for each of the different kinds of tests. These were obtained by dividing the number of successful shots by the number of attempts.

Percentages (mu)					
Single Rim			Double rim		
	standard technique	chest technique		standard techniq	chest technique
free throw	0.45	0.2	free throw	0.6	0.3
45 deg left	0.3	0.7	45 deg left	0.35	0.25
45 deg right	0.45	0.4	45 deg right	0.3	0.5
layups			layups		
left side	0.25		left side	0.25	
right side	0.7		right side	0.55	

Below are the f-test scores that compare the standard deviation of shots for the single and double rims. By using a rigorous alpha of 50%, one can very confidently say that the variances of the two tests are the same. This is because the F scores are in the range of 0.73 and 1.3, and not in the tails. Thus, the pooled variance t-test is used below.

F-test scores: S1/S2^2		
	standard technique	chest technique
free throw	1.03125	0.761904762
45 deg left	0.923076923	1.12
45 deg right	1.178571429	0.96
layups		
left side	1	
right side	0.848484848	
f test		
%	score	
0.25	0.730366924	
0.75	1.369174817	

All of the confidence intervals below are for alpha=40% for a rigorous test. The “lower” column shows the lower bound of the confidence interval for that test set, while the “upper” column shows the upper bound.
This shows mixed results; half the tests reject the hypothesis and the other half say you cannot reject the hypothesis.

CI's for T-test for all trials				
	standard technique		chest technique	
	lower	upper	lower	upper
free throw	-0.286329895	-0.013670105	-0.218769424	0.018769424
45 deg left	-0.179149527	0.079149527	0.326895946	0.573104054
45 deg right	0.017931471	0.282068529	-0.236679012	0.036679012
layups				
left side	-0.119569228	0.119569228		
right side	0.017931471	0.282068529		

Next, a 95% confidence interval was used. The values for the t-test shown below are used for subsequent tests, unless otherwise specified.

T test	
%	score
0.025	-2.024
0.975	2.024

CI's for T-test for all trials				
	standard technique		chest technique	
	lower	upper	lower	upper
free throw	-0.474205977	0.174205977	-0.382445441	0.182445441
45 deg left	-0.357130351	0.257130351	0.15724638	0.74275362
45 deg right	-0.164072027	0.464072027	-0.425036212	0.225036212
layups				
left side	-0.284347452	0.284347452		
right side	-0.164072027	0.464072027		

There is only one trial that does not support the hypothesis (highlighted in yellow). That is because this trial had the biggest difference in success rates for the two shots.

The next test explored whether shooting from the left or the right made any difference. This was done using the same data, but only comparing the layups on the left and right sides and shots from 45 degrees to the left or right. Note: “Hoop1” is defined as the dingle-rimmed hoop and “Hoop2” is the double-rimmed hoop. As before, an f-test is conducted on the sample variances to determine what type of t-test will be used.

F-test scores: S1/S2^2			
	hoop1	hoop2	
layup	0.892857143	0.757575758	
45 deg L/R	0.848484848	1.083333333	(std)
	0.875	0.75	(chest)

f test	0
%	score
0.25	0.730366924
0.75	1.369174817

All of the variances are assumed to be equal since they are within the tails of the f-test. Using the pooled variance equations, the following confidence intervals were constructed.

CI's for T-test for all trials				
	standard technique		chest technique	
	lower	upper	lower	upper
hoop1	-0.464072027	0.164072027	-0.014	0.6141
hoop2	-0.257130351	0.357130351	-0.557	0.0571
layups				
hoop1	-0.74275362	-0.15724638		
hoop2	-0.59275362	-0.00724638		

The results show that layups form the left and right most likely do not have the same success rate. This is true for both hoops, which makes it easy to reject the hypothesis that they would be equal. However, it is important to note that the upper bound of the layups for hoop 2 is very close to zero, which means the hypothesis almost cannot be rejected.

For the third and final test, the comparison is between the techniques used for shooting. This is only applicable to the distance shots, which are the free throw, and 45 degree shots. Below are the results of the F-test.

F-test scores: (S1/S2)^2		
	hoop1	hoop2
free throw	1.5469	1.1429
45 deg left	1	1.2133
45 deg right	1.0313	0.84

f test	0
%	score
0.25	0.7304
0.75	1.3692

Since the free throw for hoop 1 had very different variances for the two techniques, the pooled variance could not be used. This requires a different t-test with a different degree of freedom

(dof). The dof used for the t-test was calculated to be 36 using the non-pooled dof equation. This changes the values of the t-scores for this particular test, which are shown in the table below.

T-test dof = 36	
%	score
0.025	-2.028
0.975	2.028

All other test will use the same t-scores used previously. Below are the confidence intervals for these tests.

CI's for T-test for all trials				
	hoop1		hoop2	
	lower	upper	lower	upper
free throw	-0.047	0.547	-0.011	0.6115
45 deg left	-0.701	-0.099	-0.199	0.3991
45 deg right	-0.274	0.3742	-0.515	0.1149

Only the 45 degree shot from the left indicates that there is a difference in performance between the two techniques, but the hypothesis cannot be rejected because the other confidence intervals contain zero.

Conclusions

Based on the results above, for the 95% confidence interval, the hypotheses cannot be rejected because only one or two trials suggest that they should be rejected. One exception to this is for the test on whether the left or right side affects performance. Here, it is safe to say that the side does make a difference, but only for layups. The hypothesis still cannot be rejected for the other cases. Indisputably, the results were tainted by human error. It is very possible that I had low average performance with one rim and high average performance on the other rim for reasons unrelated to the conditions of the experiment. It would have been better for the experimental data to contain trials from many people with “decent” shooting skills.

References

[1]
Hoops Junction. “Why Shooting On Double Rims Makes You A Lights Out Shooter.” *Hoops Junction*, 31 July 2017, www.hoopsjunction.com/how-double-rims-can-help-your-game/#sthash.6u0Nsv2S.dpbs

[2]
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